EXECUTIVE SUMMARY

of the Final Report for

INTEGRATED ON-LINE SYSTEMS APPROACH

To

NAVY SUPPLY OPERATIONS

Contract No. Nonr 3804(00) July 1961

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Prepared by

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Introduction

The Navy Supply System, in common with many similar large-scale operations, has encountered a fundamental difficulty associated with its growth. With increase in the size of systems of this nature, a point is reached where linear enlargement of facilities and staff without a basic change in the system does not permit handling of the required increase in business. Records become unwieldy, physical access to the stock becomes slow and inefficient, and service deteriorates to an unacceptable standard. Filing systems, with more rapid access, and processing methods using machine aids, extend considerably the volume of business which can be handled efficiently. Decentralizing the business among smaller, more manageable units (multiple stock points, etc.) permits more transactions to be conducted with acceptable delays. These expedients have kept the Navy Supply System functioning and rendering acceptable service in spite of mounting difficulties. The inexorable growth of the system continues, however, and with it an increasing need for a re-examination of the entire problem. Some of the difficulties which are a product of large system size are: errors, delays, inefficiencies, and the inability to predict performance accurately. All of these factors can be evaluated to some extent in terms of cost per transaction, and the potential savings to be expected from improvements justify considerable investigation of new methods or equipment.

The handling of the actual material has received considerable attention, and improved arrangements have evolved, such as automated warehousing, improved storage techniques, shipment consolidation planning, etc. The associated data system, including the inventory records, orders, requisitions, accounting, etc., presents just as challenging a field, particularly when the over-all data requirements are considered as part of a single problem. This aspect has been studied by BuSandA and the concept of a total systems approach has been documented. This concept involves an integrated treatment of all aspects of data associated with material handling. The availability of large, fast, reliable data processors prompts the extension of this line of reasoning to a concept of nationwide data and material handling in a single system which operates in "real time", that is, inputs to the system are accepted and processed as soon as they are entered, and response made as soon as the processing is completed. This type of operation describes an "on-line" centralized data processing system.

Integrated On-Line System Characteristics

The application of integrated on-line data processing techniques to the total Naval Supply System implies a nation-wide data processing and communications system operating on a 24-hours-per-day basis. Users and management would have immediate access to the total supply situation at all times by means of a communications network linking stock points, ICPs, management control points, customer locations, and data processing centers. (See Figures 1 and 2).

Transactions (inquiries, requisitions, receipts, reconciliations, etc.) are entered at random into the system through remote on-line input/output devices located at convenient user locations. Each transaction is immediately transmitted via the communications system to the processor site where, according to its type and content, files are searched, processed and updated, required action messages are generated and transmitted, and the originator is immediately notified of the action taken on his transaction.

The integrated system would fill requisitions on the basis of the total stock status at all stock points, determining the best method of issuing material by such criteria as customer location, priority, date required, consolidation requirements, transportation schedules, and predicted stock point loads. The customers would be immediately informed of the predicted delivery date of material, allowing them to adjust their operations to the total supply capabilities in an optimum manner.

Information would be continuously available to management concerning the status of all inventory items. Potential bottlenecks in the complex chain of steps between request and delivery of material to the customer would be detected and immediately reported to management for action. Tight control of receipt of new material would be achieved by reconciling all stages of the contractor procurement - due in - receipt chain.

Stock point workloads could be controlled by maintaining work schedules for all stock points in the data processor and routing requests to the stock point most capable of supplying the requisition. Requisitions would be held in an In Process File in the data processing system until the combination of priority, date required, workload schedules, and transportation schedule allows immediate issue and shipment of material from the stock point, thereby minimizing delays in the warehouse area and in shipping operations.

Use of input devices tied directly on-line to the data processor would allow the data processor to screen incoming messages for errors in key data, such as FIIN, quantity, and unit of issue prior to entry of the message into the main processing cycle.

While the on-line communication system is limited to the continental U.S., requisitions and other transactions transmitted from overseas locations could be entered through semi-automatic means if message formats were made compatible with the system.

Scope of Study

The scope of the study covers the investigation of current methods of handling the supply problem from the standpoint of their application to a total data processing system. The study includes a delineation of the basic supply functions and their implementation in an integrated system. It seeks a determination of current data and traffic rates, and future trends to fix the size and capacity limits of the system. It offers a solution to the problem within the framework of current and future needs, and it furnishes the groundwork for an economic justification by means of rough costs of equipment and services to implement the suggested solution. The study was limited to areas of the Navy Supply System which might affect the cost and practicality of an on-line system. Specifically, the study covered the functions of maintaining inventory records; processing customer requests for materials; processing customer and management inquiries; issuing of picking, packing, and shipping instructions and reconciling of these transactions with the associated records; and exchanging information between inventory records and ICPs concerning procurement-receipt operations. The report is divided into three parts: Problem Definition; Problem Solution; Cost Analysis, Conclusions and Recommendations.

Problem Definition - Part I

Problem Definition consists of the Functional, Data Transmission, and Data Storage Requirements imposed by the Navy Supply requirements on an on-line data processing system.

All data processing is done in a centralized complex of one or more processing sites. (See Figures 1 and 2.) The inventory records and other files for each stock point and customer are held in this centralized complex. Each stock point and various user locations have direct on-line data communication with the centralized complex via the communication system. Since all records and transactions within the system are centralized, inventory and requisition control is exercised on both a total system and individual stock point level in accordance with the data processing programs. (See Figure 6.) The programs required for handling the various types of transaction and management reports and requests are stored internally and are called up for use as required.

Charts 1 and 2 show the data transmission input and output message statistics for the total system, based on Fiscal Year 1960 data. The peak input messages were derived at 21.5 per second. Sixty-six percent of all messages pertain to the Requisition-Issue-Reconciliation process, 27% to the Reorder-Due-In-Receipt process, and 5% to Inquiry messages.

Chart 3 shows the data storage requirements for the major immediate-access files in the system. For the total system there is a requirement for approximately 920 million digits of immediate access storage. The major portion of this storage (71%) is used for storing Inventory Stock Status Records. The In Process Requisition File requires 20% of the total storage, and the Due In Record File requires 6% of the total storage. The remainder of the storage consists of miscellaneous records, lists, tables, and programs storage. Figures 3 and 4 show the system file organization and the transaction flow against these files.

Problem Solution - Part II

On the basis of the functional requirements and system statistics determined in Part I of this study, several system configurations were investigated within a framework of presently available hardware and techniques. This investigation was not intended to provide solutions for actual implementation. The object was to provide rough cost estimates of sufficient accuracy for evaluation of the desirability of further action, and to indicate the significant areas affecting cost and application so that these areas may be concentrated on in further system analysis. The solutions were formulated to the extent possible in terms of generalized units of hardware rather than specific manufacturer's products.

Figure 5 illustrates the major hardware components of an integrated on-line system and their interrelationships. The flow of information through the system is as follows:

a) Input messages are entered into the system through appropriate input/output devices at each activity convenient to the user.
b) These messages are then transmitted via the communications network to the data processing site where they are stored in the Interface Buffer.
c) When a data processor is available for a new message, it will interrogate the Interface Buffer for the presence of an input message.

d) The input message is transferred to the data processor, analyzed, and the appropriate action taken. Such action requires access to peripheral equipment, such as drums, discs, tapes, etc.

e) When the processing is completed, the data processor generates an appropriate reply which is transferred to the output section of the Interface Buffer.

f) When the desired communications line is not busy, the reply message is transferred from the buffer to the communications network.

g) The reply message is then routed through the communications network to the appropriate input/output device and displayed to the user.

Two basic configurations were analyzed; one with a single centralized processor site, and one with two regional processor sites. The analysis of the single centralized processor site included consideration of duplicating the processor installation at a fallback location at some distance from the centralized site. In the single site configuration the processor facility was located at or near Norfolk, Virginia, while the dual site configuration has facilities at or near Norfolk and Oakland, California. These locations are logical centers of supply message traffic.

In both of these approaches the processing sites were linked to remote input/output devices at stock points and customer locations through a high-speed (2400 bits/second) communications network. The effects of maximum and minimum traffic rates and different methods of providing fallback in case of a processing site breakdown were also analyzed. Maximum traffic rates were established on the basis of handling peak message traffic on-line (FY 1960 statistics). Minimum traffic rates were established on the basis of handling, on-line, only those messages pertaining directly to requisitions, inquiries, and receipts. Non-immediate invoice and reconciliation messages would be scheduled for transmission during off-peak hours. In addition, the effects of system growth were analyzed on the basis of a 100% increase in the FY 1960 maximum traffic.

Cost Analysis, Conclusions and Recommendations

Chart 4 shows a summary of the systems analyzed and their estimated equipment costs. All systems include provisions for extensive fallback in the communications network and for component failure at processing sites (i.e., in all systems each processing site has more than one computer to provide fallback in case of a single computer breakdown).

System 1 on the chart is for a single centralized processing site with minimum traffic rates. The estimated equipment rental for this system is $463,000 per month. This is based upon amortizing the cost of the equipment over a 36-month period.

System 2 is similar to System 1, but provides maximum on-line traffic rates, increasing the cost by 26% to $584,000 per month rental.

System 3 is a regional system with one processing site located in the east (Norfolk) and one processing site in the west (Oakland), both with maximum on-line traffic. In this system, if an entire processing site is destroyed, the other site will be able to continue to handle only its share of the total load (50% fallback). Compared with the equivalent single-site maximum-traffic system (System 2), which has no fallback in case of complete destruction, the two-processing-site system increases the costs by 21% to $705,000 per month.

System 4 is a centralized system with minimum on-line traffic, similar to System 1 but with complete fallback. This fallback is provided by having a second, duplicate processing site located at some distance (say 100 miles) from, and operating in parallel with, the first processing site. In case of destruction of either site, the other will be able to handle the entire processing load. This 100% protection increases the cost 61% over System 1 to $747,000 per month.

System 5 is similar to System 4 but with maximum on-line traffic. This full fallback facility increases costs 50% over the single-site System 2, to $868,000 per month.

Systems 6 and 7 are included in the analysis to give an indication of the effect of growth on an on-line Navy Supply System. Doubling the traffic rate of FY 1960 would increase the costs of Systems 2 and 5 to $918,000 and $1,294,000 per month, respectively. Thus, a growth of 100% in transaction input rate would only increase the total system cost by approximately 50%.

Conclusions

On the basis of the requirements, solutions, and analyses given in this report, the following conclusions can be drawn with respect to an integrated on-line Navy Supply data system.

1. Integrated on-line data processing is technically feasible for the Navy Supply System. Such a system can be realized using a reasonable number of components, all within the current state of the art.
2. The equipment costs of an integrated on-line system to meet the current requirements of the Navy Supply System will fall in the approximate range of $463,000 per month to $900,000 per month. This cost range places the Navy Supply System in the size classification of integrated on-line systems currently in operation or design.
3. A 100% increase in FY 1960 peak on-line traffic will require approximately 50% increase in costs. The resulting upper limit of the cost range for the systems analyzed is $1,294,000 per month.
4. From the standpoint of data processing, a single, centralized processing site for the total Navy Supply System is superior to decentralized multiple processing sites. The processing complications of the system increase rapidly with the number of processing sites.
5. Economically, a single processing site is superior to multiple processing sites. The direct material costs of a two-site system are roughly 23% greater than for a single-processing-site system. Additional costs would be required for a two-site system due to duplication of installation, maintenance, etc.
6. It is possible to design into a centralized system sufficient fallback to maintain a major portion of the system in operation under all conditions

of failure except those arising from highly improbable combinations of circumstances, such as the destruction of both primary and duplicate processing sites.

Recommendations

The following functions of the Navy Supply System can be significantly affected by the adoption of integrated on-line data processing. These functions should be investigated thoroughly as to the best means of incorporating them into the system for the purpose of reducing costs and facilitating operations.

1. Original preparation of requisitions and inquiries for entry into the system.
2. Shipping and consolidation scheduling within a stock point. Allocation of work among stock points to even out labor requirements.
3. ICP functions such as ordering material, redistributing material, and accounting functions.
4. Technical files and technical editing procedures. Storage of large masses of technical information in a form accessible to the processor.

The following items represent the major elements contributing to the cost of an on-line system and should be given the major emphasis in preparing specifications and designing the system.

1. Input/output device specifications and locations.
2. Inventory record length and method of storage and retrieval.
3. Message statistics - peak messages per second and average message lengths.
4. Extent of fallback required.
5. Number of processing sites in the system.
6. Projected growth rate of the system.
7. Off-line batch processing requirements and management reports.
8. Determination of message types to be entered on-line and those that should be scheduled off-peak.

Chart 1. Input Messages - Total System

Message Name	Average Char/Msg	Average Msg/Day	Average		Peak	
			Msg/Sec	Char/Sec	Msg/Sec	Char/Sec
Requisition	51	106,000	3.69	188	8.44	430.0
Picking Reconciliation	14	1,000	.04	1	.09	1.2
Packing Reconciliation	16	27,000	.94	16	2.14	36.5
Shipping " Parcel Post Local Del.	29	30,000	1.04	30	2.38	69.0
Shipment Reconciliation	29	2,000	.07	2	.16	4.6
Receiving Reconciliation	29	2,000	.07	2	.16	4.6
Receipt	62	29,000	1.01	62	2.31	143.0
Availability Inq.	32	5,000	.17	5	.39	12.5
Requisition Followup	33	9,000	.31	10	.71	23.4
Inventory Inquiry	13	N	N	N	N	—
Cancel	33	N	N	N	N	—
Stock Change	34	700	.02	1	.05	1.7
Physical Inventory	27	10,000	.35	9	.80	21.6
Obligation	51	N	N	N	N	N
Planned Requirement	51					
TOTAL			7.71	326	17.63	748.1
ICP						
Due In	73	10,000	.35	26	.80	58.4
Insp. Reports from Mfrs.	47	29,000	1.01	47	2.31	108.0
Reorder Reply	9	10,000	.35	3	.80	5.6
TOTAL		49,000	1.71	76	3.91	172.0
GRAND TOTAL			9.42	402	21.54	920.1

Chart 2. Output Messages - Total System

Message Name	Average Char/Msg	Average Msg/Day	Average Msg/Sec	Average Char/Sec	Peak Msg/Sec	Peak Char/Sec
Requisition Reply	34	106,000	3.69	126	8.44	287.0
Invoice/Picking Ticket	150	92,000	3.19	479	7.26	1090.0
Packing Consolidation	68	27,000	.94	64	2.14	146.0
Ship Consolidation	89	2,000	.07	6	.16	13.7
Work Load Requirement	23	1,000	.03	1	.07	2.3
Receipt Reply	27	29,000	1.01	27	2.30	61.5
Availability Reply	21	5,000	.17	4	.38	9.1
Requisition Follow Reply	26	9,000	.31	8	.70	18.2
Inventory Status Reply	190	N	N	N	N	N
Cancel Reply	33	N	N	N	N	N
TOTAL			9.41	715	21.45	1627.8
ICP						
Reorder Notification	80	10,000	.35	28	.80	63.9
Insp. Report Reply	6	29,000	1.01	6	2.31	13.7
Due In Reply	6	10,000	.35	2	.80	4.6
TOTAL		49,000	1.71	36	3.91	82.2
GRAND TOTAL			11.12	751	25.36	710.0

Chart 3. Major System Files (Immediate Access Storage)

File Record Name	Number of Records	Total Characters	Per Cent of Total Characters
Inventory Stock Status	1,200,000	657,800,000	71.1
In Process Requisitions	552,000	182,400,000	20.0
Due In File	450,000	52,000,000	6.0
Picking, Packing, Shipping Lists	121,000	17,600,000	2.0
Requisition Primary Records	37,000	7,000,000	.7
Customer File	20,000	1,200,000	.1
Tables and Programs	----	1,000,000	.1
TOTAL		919,000,000	100.0

Chart 4. Summary of the Systems Analyzed and Their Estimated Costs

System	Processing Sites	On-Line Traffic (Maximum or Minimum Reasonably Possible)	Peak Traffic Rates	Fallback provided for the case of complete breakdown of a processing site[1]	Material Cost Millions of Dollars	Material and Line Rental[2] Thousands of Dollars per Month	% Increase of Rental over System 1
1	One in Norfolk	Minimum	1960 Peak Traffic	None	15.7	463	0
2	One in Norfolk	Maximum	1960 Peak Traffic	None	20.1	584	26
3	One in Norfolk and one in Oakland	Maximum	1960 Peak Traffic	Partial fallback provided by two, non-duplicate processing sites	24.4	705	52
4	One in Norfolk and a duplicate at some distant location	Minimum	1960 Peak Traffic	Complete fallback provided by two duplicate processing sites	25.9	747	61
5	One in Norfolk and a duplicate at some distant location	Maximum	1960 Peak Traffic	Complete fallback provided by two duplicate processing sites	30.3	868	86
6	One in Norfolk	Maximum	Double 1960 Peak Traffic	None	31.8	918	98
7	One in Norfolk and a duplicate at some distant location	Maximum	Double 1960 Peak Traffic	Complete fallback provided by two duplicate processing sites	45.3	1,294	180

[1] All systems include provisions for extensive fallback in the communication network and for component failures at the processing sites.

[2] Material rental is based on a 36 month amortization rate.

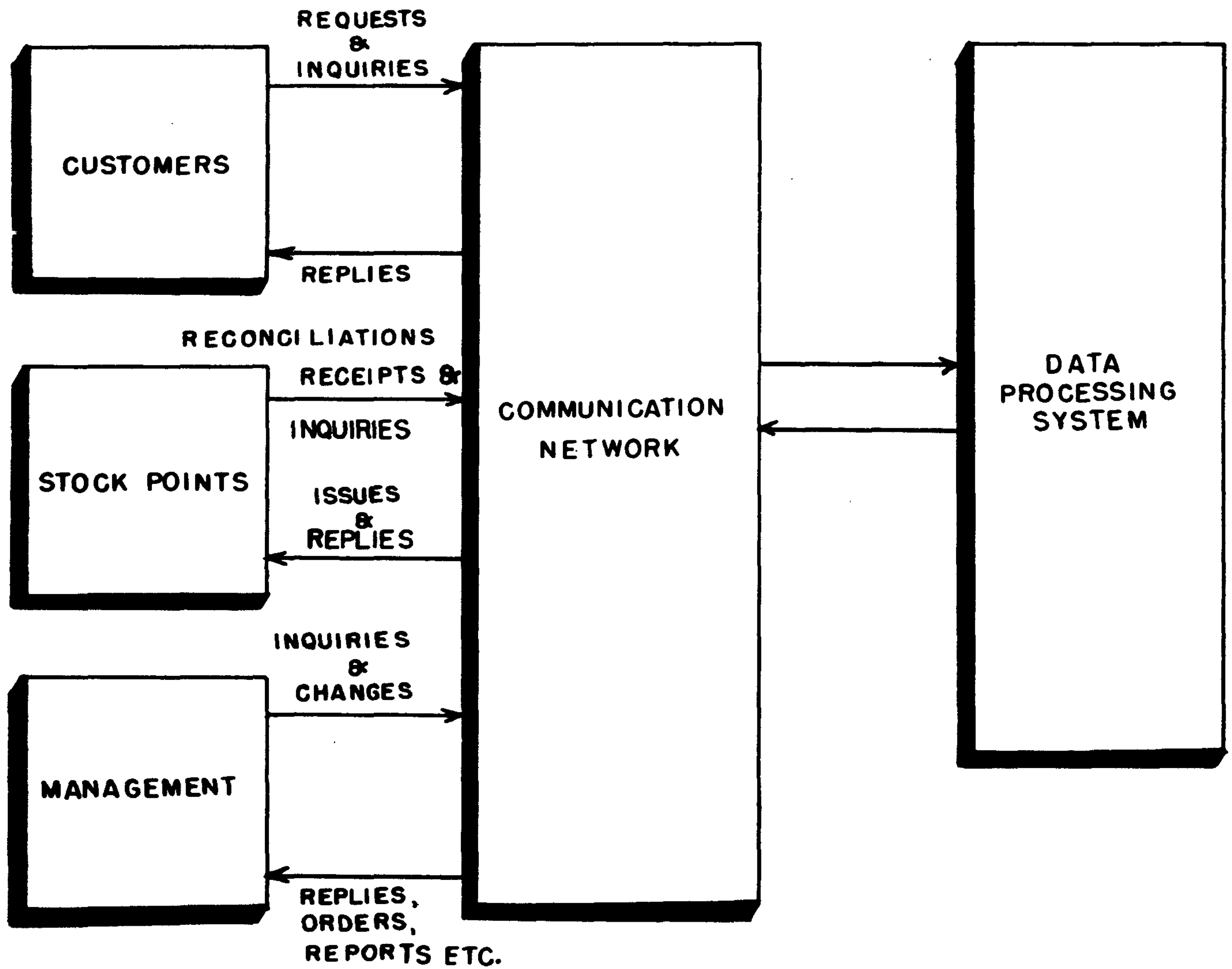


Figure 1. **Basic Information Flow Paths**

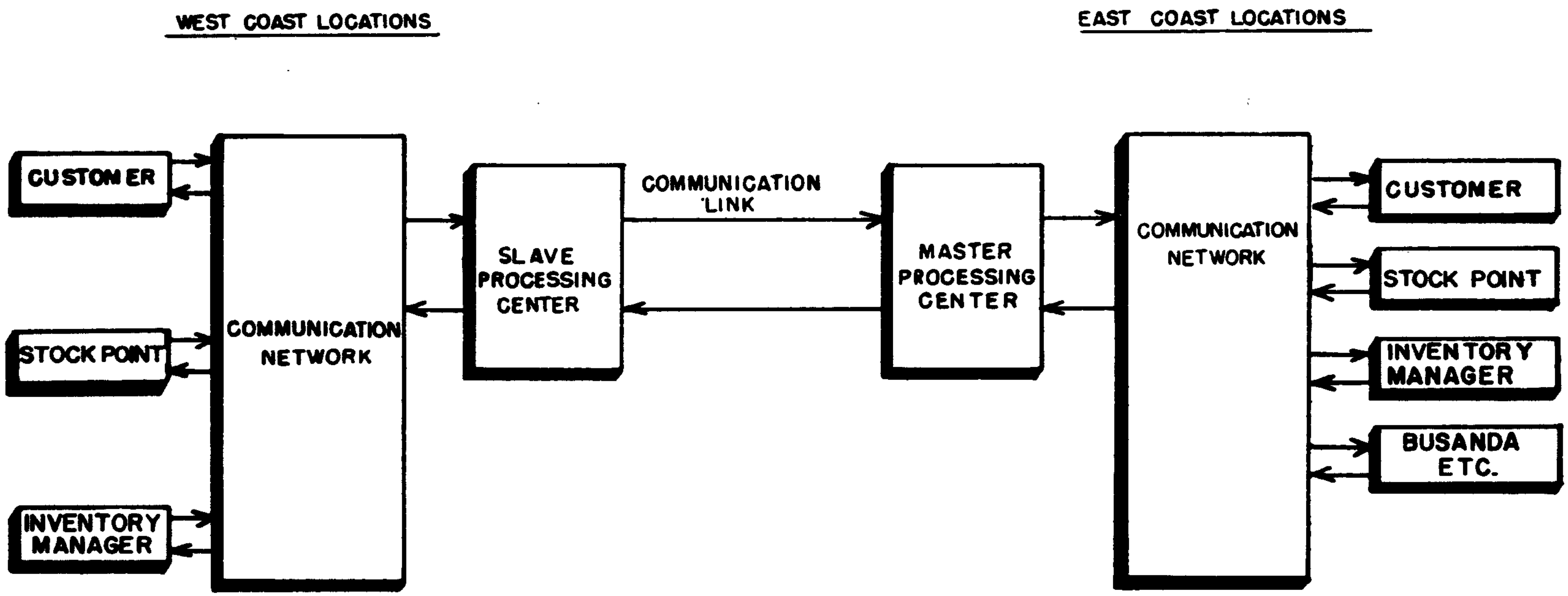


Figure 2. Information Flow in a "Two Processing Center" System

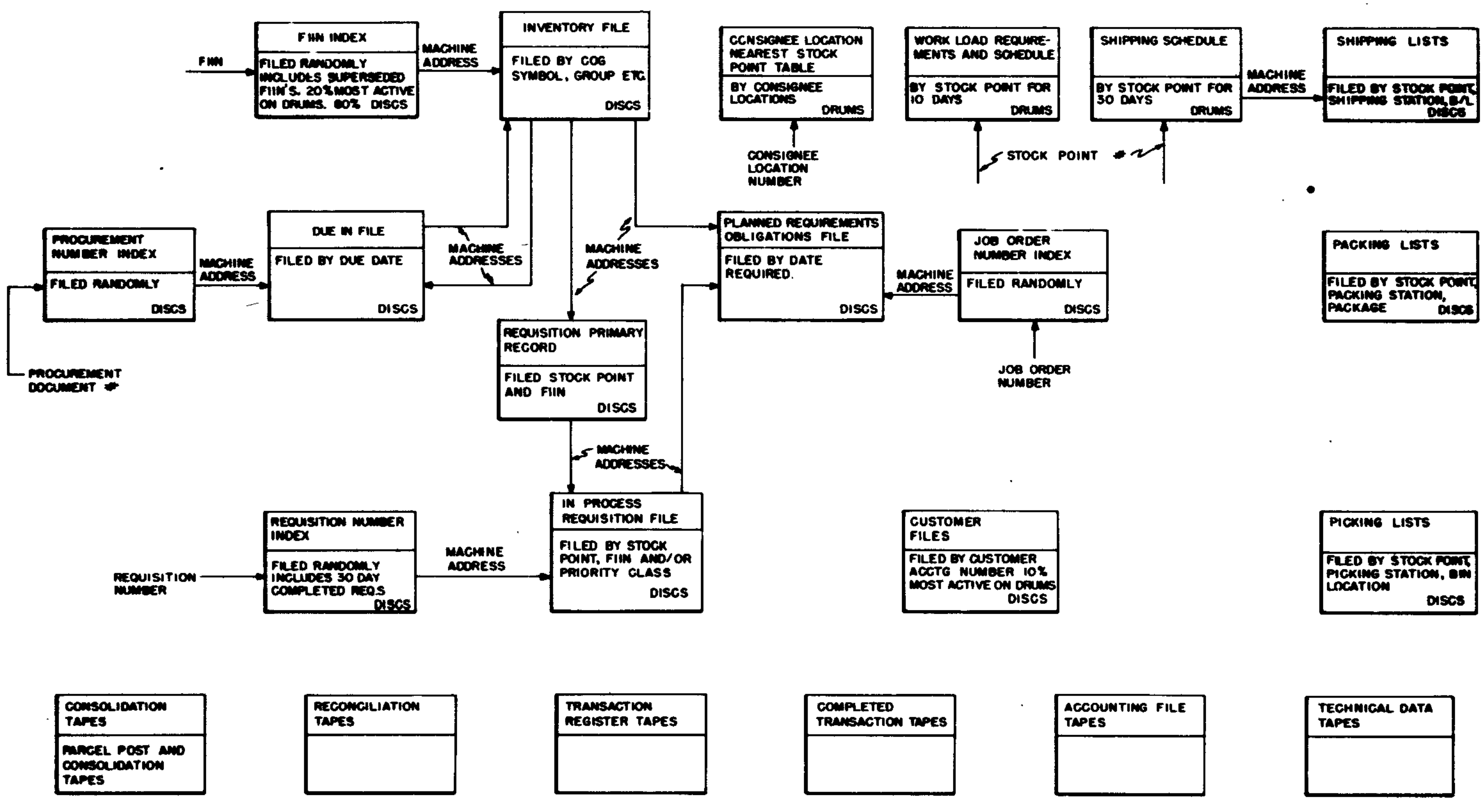


Figure 3. System File and Index Organization

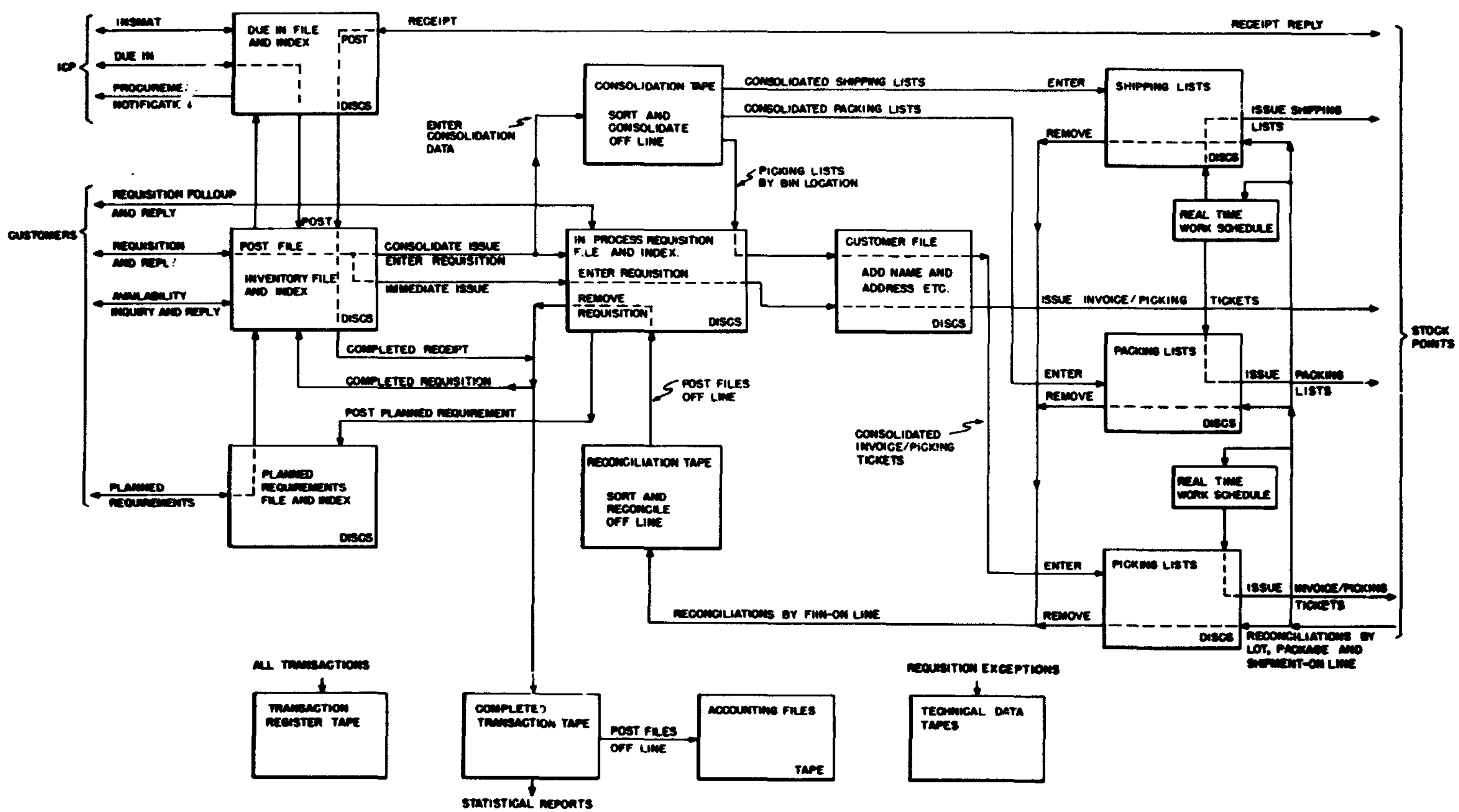


Figure 4. Generalized Transaction Flow Chart

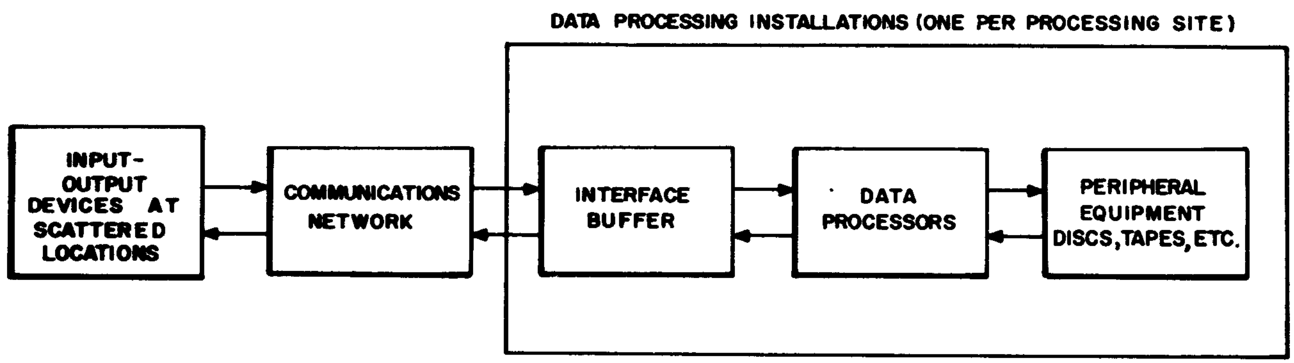
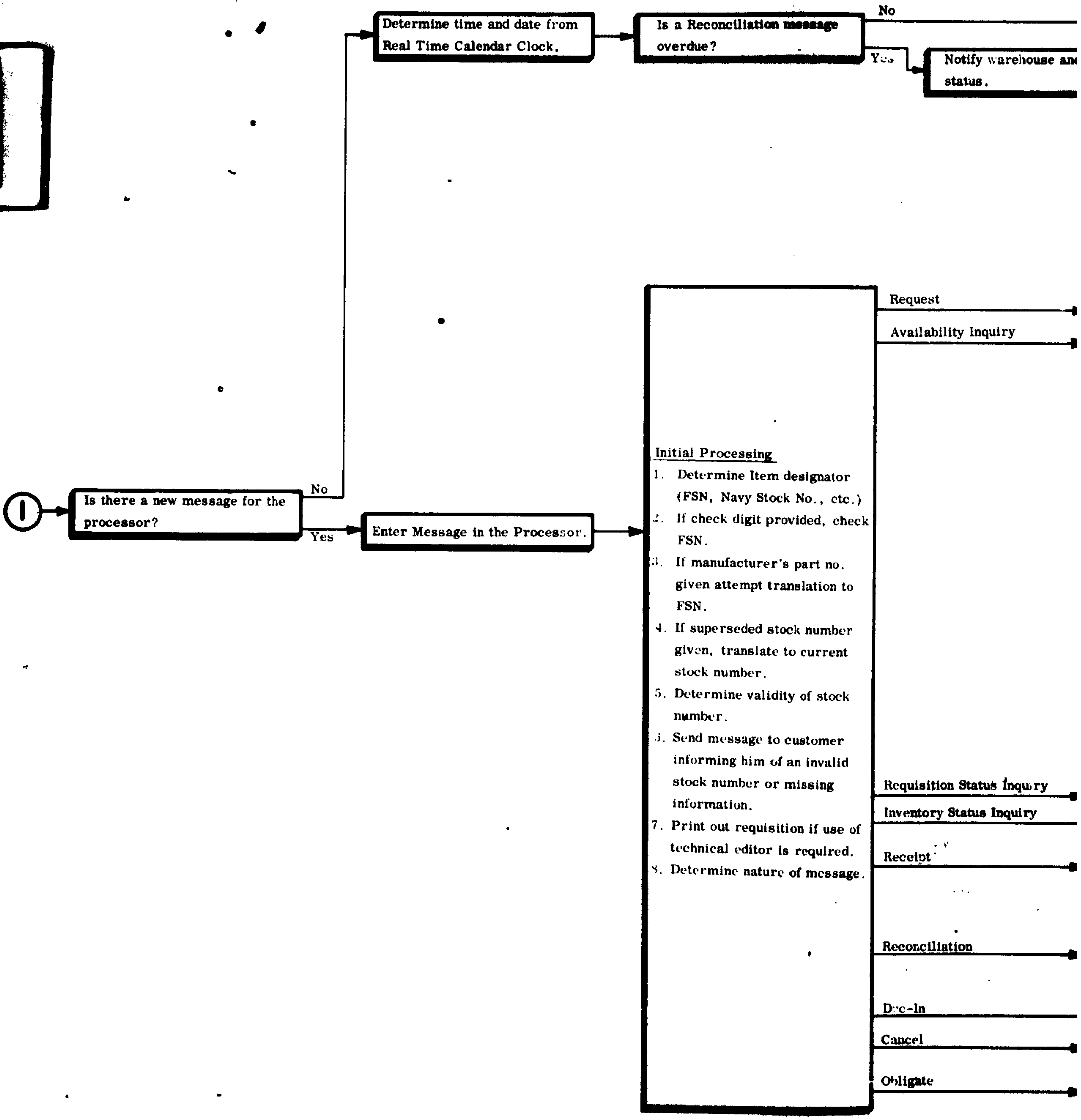
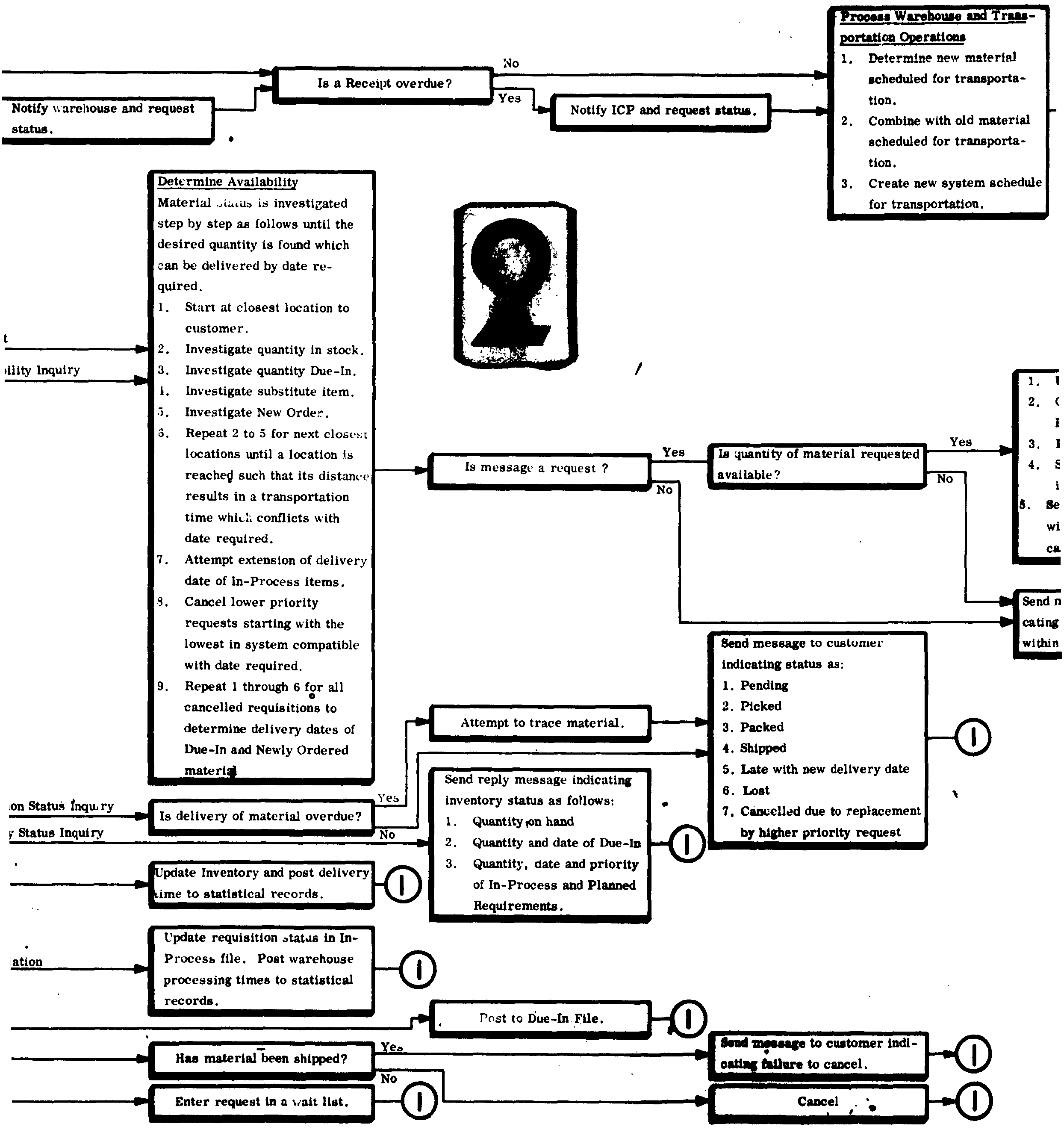


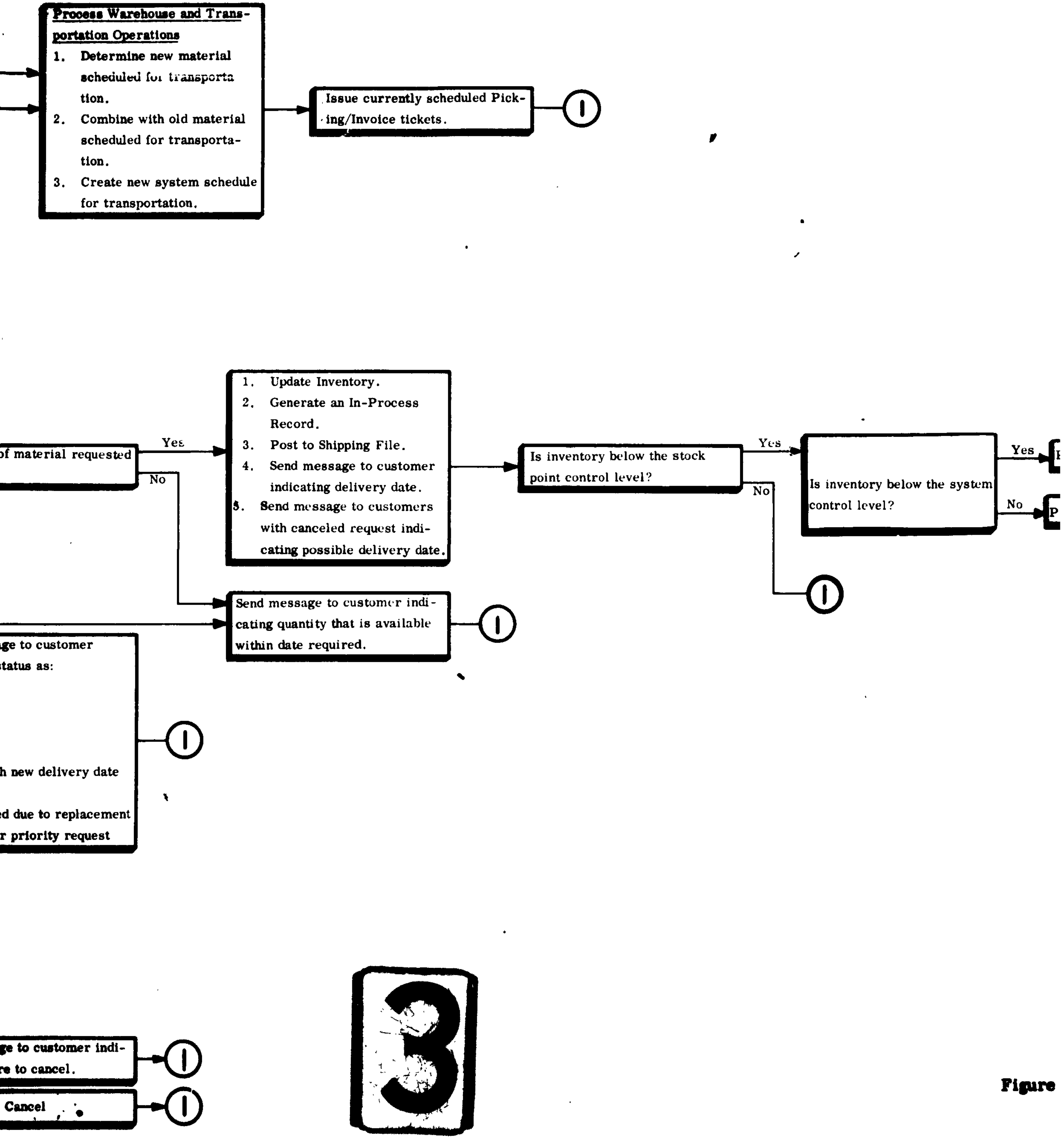
Figure 5. Major Components of an On-Line System

Data Processing Flow Chart - General





Notify warehouse and request status.
Is a Receipt overdue?
No
Yes
Notify ICP and request status.
Process Warehouse and Transportation Operations
1. Determine new material scheduled for transportation.
2. Combine with old material scheduled for transportation.
3. Create new system schedule for transportation.
Determine Availability
Material status is investigated step by step as follows until the desired quantity is found which can be delivered by date required.
1. Start at closest location to customer.
2. Investigate quantity in stock.
3. Investigate quantity Due-In.
4. Investigate substitute item.
5. Investigate New Order.
6. Repeat 2 to 5 for next closest locations until a location is reached such that its distance results in a transportation time which conflicts with date required.
7. Attempt extension of delivery date of In-Process items.
8. Cancel lower priority requests starting with the lowest in system compatible with date required.
9. Repeat 1 through 6 for all cancelled requisitions to determine delivery dates of Due-In and Newly Ordered material.
t
ility Inquiry
Is message a request ?
Yes
No
Is quantity of material requested available?
Yes
No
1.
2.
3.
4.
5. Se
wi
ca
Send n
cating
within
Send message to customer indicating status as:
1. Pending
2. Picked
3. Packed
4. Shipped
5. Late with new delivery date
6. Lost
7. Cancelled due to replacement by higher priority request
Attempt to trace material.
ion Status Inquiry
Is delivery of material overdue?
Yes
No
y Status Inquiry
Send reply message indicating inventory status as follows:
1. Quantity on hand
2. Quantity and date of Due-In
3. Quantity, date and priority of In-Process and Planned Requirements.
Update Inventory and post delivery time to statistical records.
iation
Update requisition status in In-Process file. Post warehouse processing times to statistical records.
Post to Due-In File.
Has material been shipped?
Yes
No
Send message to customer indicating failure to cancel.
Enter request in a wait list.
Cancel


Process Warehouse and Transportation Operations
1. Determine new material scheduled for transportation.
2. Combine with old material scheduled for transportation.
3. Create new system schedule for transportation.
Issue currently scheduled Picking/Invoice tickets.
1
of material requested
Yes
No
1. Update Inventory.
2. Generate an In-Process Record.
3. Post to Shipping File.
4. Send message to customer indicating delivery date.
5. Send message to customers with canceled request indicating possible delivery date.
Is inventory below the stock point control level?
Yes
No
Is inventory below the system control level?
Yes
No
P
1
Send message to customer indicating quantity that is available within date required.
1
ge to customer
tatus as:
1
h new delivery date
d due to replacement
r priority request
ge to customer indi-
re to cancel.
1
Cancel
1
3

Figure

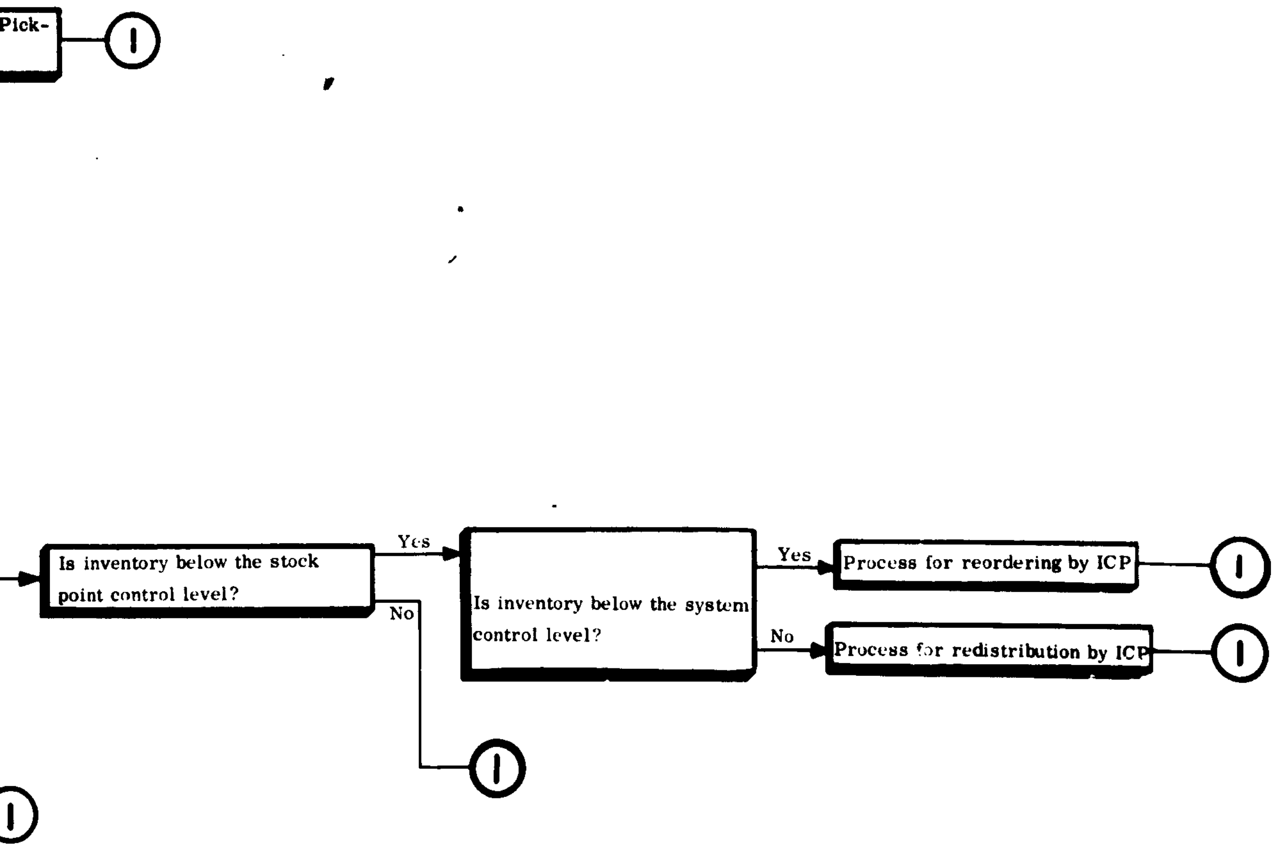


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Figure 6. Data Processing Flow Chart - General